REMARKS

The Office Action mailed April 6, 2007, has been carefully reviewed and, by this Amendment, Applicants have amended claim 12 and added claim 26. Claims 1-26 are pending in the application. Claims 1, 14, 21 and 26 are independent. Claims 21-25 have been withdrawn.

The Examiner rejected claim 12 under 35 U.S.C. 112, second paragraph, as being definite. Applicants have amended claim 12 to clarify that the catalyst being claimed include copper, potassium and vanadium *in combination*, not in the alternative. This is supported in the specification on page 19, lines 9-22. Withdrawal of the rejection is requested.

The Examiner rejected claim 1 under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 3,671,419 to Ireland et al. ("Ireland") in view of U.S. Publ. No. 2002/0122965 A1 to Yu. Also under 35 U.S.C. 103(a), the Examiner rejected claims 2, 5, 6, 11 and 13 as being unpatentable over Ireland in view of Yu and further in view of Olsen ("Unit Processes and Principles of Chemical Engineering", July 5, 1932, D. Van Nostrand Company, Inc., ch. 1, pages 1-3), rejected claim 7 as being unpatentable over Ireland in view of Yu and Olsen and further in view of U.S. Patent No. 5,124,140 to Okada et al. ("Okada"), rejected claims 8-10 as being

unpatentable over Ireland in view of Yu and further in view of U.S. Patent No. 3,862,899 to Murphy et al. ("Murphy"), rejected claims 3 and 4 as being unpatentable over Ireland in view of Yu and further in view of U.S. Patent No. 6,464,857 to Miller, rejected claim 12 as being unpatentable over Ireland in view of Yu and Olsen and further in view of U.S. Patent No. 3,671,421 to Peck, rejected claims 14, 15, 17 and 18 as being unpatentable over Ireland in view of Yu, Murphy and Okada, rejected claim 16 as being unpatentable over Ireland in view of Yu, Murphy, Okada and Miller, rejected claim 19 as being unpatentable over Ireland, Yu, Murphy, Okada and further in view of U.S. Patent No. 6,815,106 to Salvador et al., and rejected claim 20 as being unpatentable over Ireland, Yu, Murphy, Okada and Peck.

As set forth in claims 1 and 14, the present invention is directed to a compact and efficient fuel processor operating at pressures higher than one atmosphere and temperatures above 300°C for reforming distillate hydrocarbon fuels containing sulfur to obtain high quality hydrogen product. The fuel processor includes a separation assembly for converting and separating a sulfur-containing distillate fuel feed into an aliphatics-rich and sulfur-depleted gas stream and an aromatics-rich and sulfur-rich liquid stream; a desulfurization assembly for receiving the

aliphatics-rich and sulfur-depleted gas stream exiting the separation assembly and for removing hydrogen sulfide therefrom to output desulfurized gas; a combustion assembly for receiving the aromatics-rich and sulfur-rich liquid stream exiting the separation assembly and for combusting the liquid stream with air to yield process heat; and a reforming assembly in which process heat from the combustion assembly is used to generate steam and convert the desulfurized gas exiting the desulfurization assembly to a hydrogen-rich stream. This is not shown or suggested by the prior art.

Ireland is directed to a method for refining crude oil into useful products. In the abstract thereof, it is explicitly stated that a "significant feature" of this invention is the recycle of the sulfur-rich and aromatics-rich liquid stream (see liquid recycle 41 of Ireland Figure 1) for further processing, specifically hydrogenation and cracking, to improve the yield of "premium products", i.e. gasoline-range hydrocarbons. It was clearly not at all obvious to the inventors of Ireland that this liquid stream should be combusted; on the contrary, combustion of this liquid recycle stream would have eliminated a significant feature of their invention.

The heat source for driving the endothermic cracking and reforming operations in Ireland's crude oil upgrading process is unspecified. If combustion, rather than recycle, of the liquid stream (41) were an obvious or desirable modification of Ireland's process, it is reasonable to assume that the inventors thereof would have described this embodiment as a way of providing heat for the endothermic operations of the process. Ireland describes no such embodiment. Instead, it is clear from Ireland that their invention is meant to be an efficient refining process for conversion of crude oil to gasoline-range products at improved yield; as such, the process taught by Ireland is not meant to be compact. Nor is there anything in Ireland to suggest that close integration of distillate fuel separation, desulfurization, combustion, and reforming operations leads to a more compact processor.

As set forth in claims 1 and 14, by contrast, the present invention claims a *compact* distillates fuel processor with effective sulfur removal. This claimed subject matter is in no way an obvious modification or derivation of the crude oil upgrading process described by Ireland.

Yu is directed to a water-gas-shift reactor in which oxygen is injected to reduce the amount of carbon monoxide so that

less catalyst is needed to effect the water-gas shift. Contrary to the Examiner's conclusion, Yu does not teach "an apparatus for hydrogen production", but rather a process for operating a fuel cell system. The fuel cell is integral to the invention of Yu, as the fuel cell anode off-gas must be recycled to fuel the combuster 10. A fuel cell is not an integral unit operation of the compact fuel processor described in the present application. Further, combustion of both the anode off-gas and a significant fraction of the fuel feed stream, as taught by Yu, would produce more heat than required for reforming operations. On the other hand, combustion of the anode off-gas and only an insignificant fraction of the fuel feed stream would not allow for effective sulfur removal. Hence, the process for operation of a fuel cell described in Yu is in fact incompatible with the fuel processor claimed by the present invention. Yu does not teach combustion of a sulfur-rich and aromatics-rich liquid stream from a separation assembly, and inclusion of these separation and combustion assemblies in the process described by Yu would make combustion of the anode off-gas unnecessary.

For at least the foregoing reasons, claims 1 and 14 are patentable over Ireland in view of Yu. New claim 26 is also patentable thereover for at least the same reasons.

Applicants also want to comment on the citation to the Olsen textbook. The Examiner correctly notes that Olsen, along with many other chemical and mechanical engineering textbooks, teaches the use of recuperating heat exchanges as a means of improving process efficiency and economics. It is widely known to those skilled in the art of process design that transfer of heat from an exit stream to preheat a cold inlet stream can benefit overall process efficiency. However, it is not at all obvious that combustion of an internal process stream will necessarily improve process efficiency or compactness, and neither Olsen nor any other prior art teaches that combustion of valuable hydrocarbon streams is always an obvious technique for achieving great process economies. In most hydrocarbon fuel processing schemes, including that of Ireland, it is desired to recover as much of the hydrocarbon feedstock as possible in the refined products; combustion of an energy-rich hydrocarbon stream is to be avoided if at all possible. However, the unique arrangement of assemblies claimed by the present invention provides a compact means of processing sulfur-containing distillate fuels. Thus, process economies and efficiencies are of secondary importance relative to compactness and effective sulfur removal. It would not, therefore, be obvious in the least to one skilled in the art of process design

that combustion of a particular process stream would improve the compactness of the process. However, as described in the "Detailed Description Of The Invention" section of the present application, integration of the separation, combustion, and reforming operations of a distillate fuel processor can improve compactness while providing for effective sulfur removal.

Furthermore, although combustion of a hydrocarbon fuel in air may be a conventional means of producing heat, it is not at all obvious that a distillate fuel feed stream can be separated into two streams in such a way that one stream can be combusted to provide adequate heat for reforming the other, while simultaneously diminishing the concentrations of sulfur and aromatics in the reformed stream. As set forth in Figures 5(a-c) of the present application, the carbon masses of three different fuels, namely diesel, kerosene, and JP-8, can be separated by volatility (indicated by GC retention time in the figures) in such a way that the less volatile 1/3 fraction contains a greater portion of sulfur than the more volatile 2/3 fraction. As explained in the specification page 15, lines 19-20, "The thermodynamics of steam reforming require that approximately one-third of distillate fuel feed must be combusted to balance the heat demands of reforming the other two-thirds." This fact is neither obvious nor widely known;

it is learned only by performing a complex iterative set of calculations using the enthalpies of the combustion and reforming reactions of a specified suite of hydrocarbon compounds which, taken together, function as a surrogate for the fuel in question. It is also neither obvious nor well known that the hydrocarbon and sulfur distributions of hydrocarbon fuels are typically such that the higher-boiling third of the fuel's mass contains a greater concentration of sulfur species than the lower-boiling two-thirds of the mass. In fact, as Figure 5(d) shows, this particular sulfur distribution is not typically the case for gasoline-range fuels. It is certainly in no way obvious that the combustion/reforming heat balances and the sulfur distributions of distillate fuels can be exploited together in the unique arrangement of operations and assemblies described in claims 1, 14 and 26 to yield a compact fuel processor with effective sulfur removal.

In sum, Ireland includes operations for separation of hydrocarbon streams into light and heavy fractions. Yu includes a combustion operation. Olsen teaches the use of recuperating heat exchangers to improve overall process efficiency. Applicants are not claiming to have invented any of these particular unit operations of the claimed fuel processor. What is being claimed, as detailed in claims 1, 14 and 26 and illustrated in Figure 1 of

the present application, is a unique means of integrating separation, desulfurization, combustion, and reforming operations to yield a compact fuel processor with effective sulfur removal. Respectfully, the specific design as claimed is not obvious from Ireland, Yu, Olsen, or any other of the cited prior art references, whether taken alone or in any combination thereof.

Claims 2-13 and 15-20 are also in condition for allowance as claims properly dependent on an allowable base claim and for the subject matter contained therein.

In view of the foregoing, it is respectfully submitted that the present application is in condition for allowance. Should the Examiner have any questions or comments, the Examiner is cordially invited to telephone the undersigned attorney so that the present application can receive an early Notice of Allowance.

Respectfully submitted,

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